In Pursuit of Low-Cost Lab Automation: Designing Frugal Twins by Extending Capabilities of Liquid Handlers and 3D Printers

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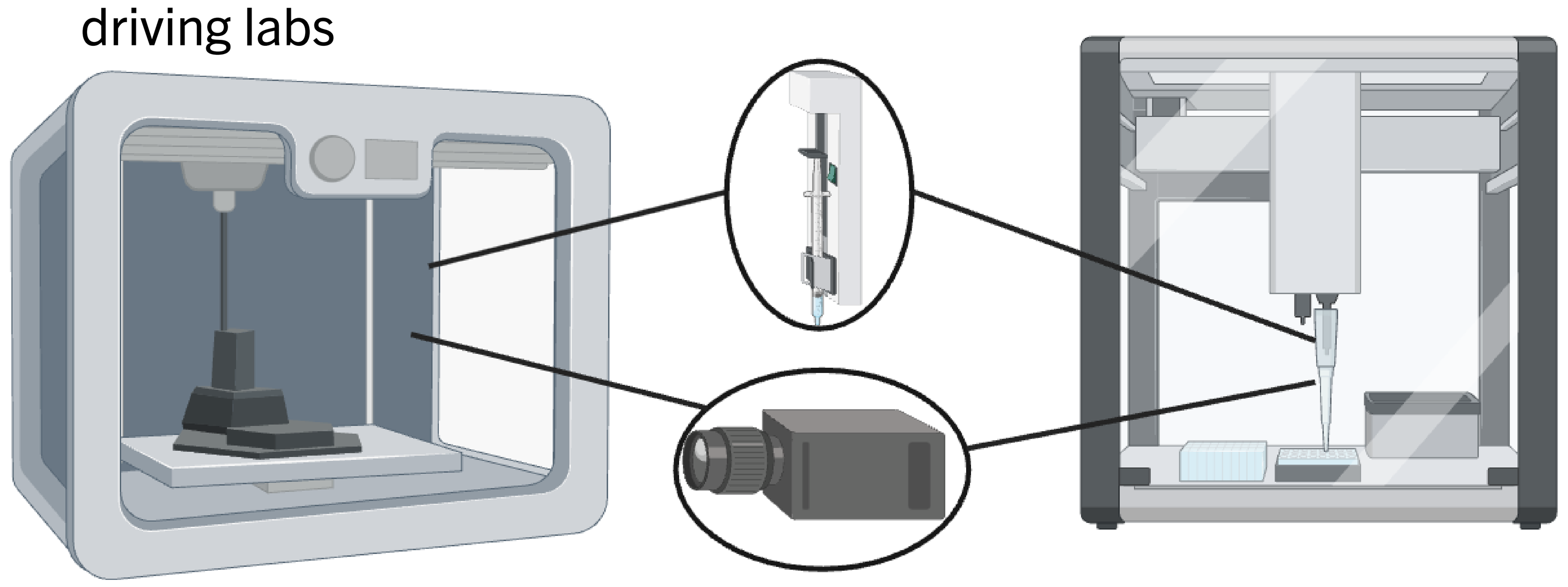
Introduction

- We use the Opentrons OT-2 and Prusa i3 Mk3S as base equipment to create frugal twins of lab tools
- Enhance the base design's functionalities beyond the original scope
- Propose usage of machine learning to accelerate tool generation and creation

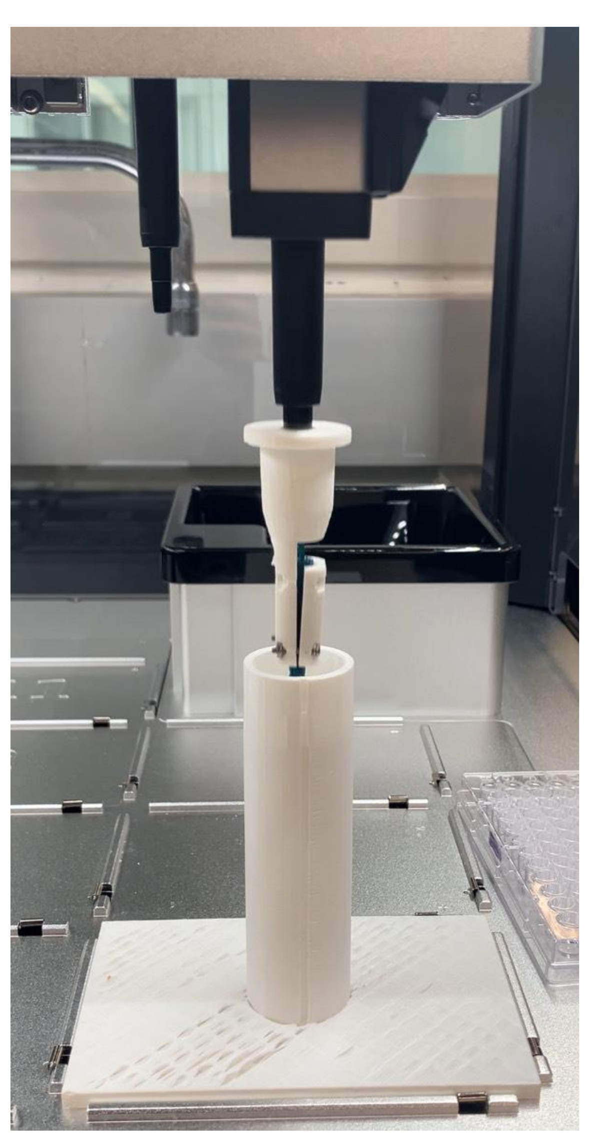
Motivation

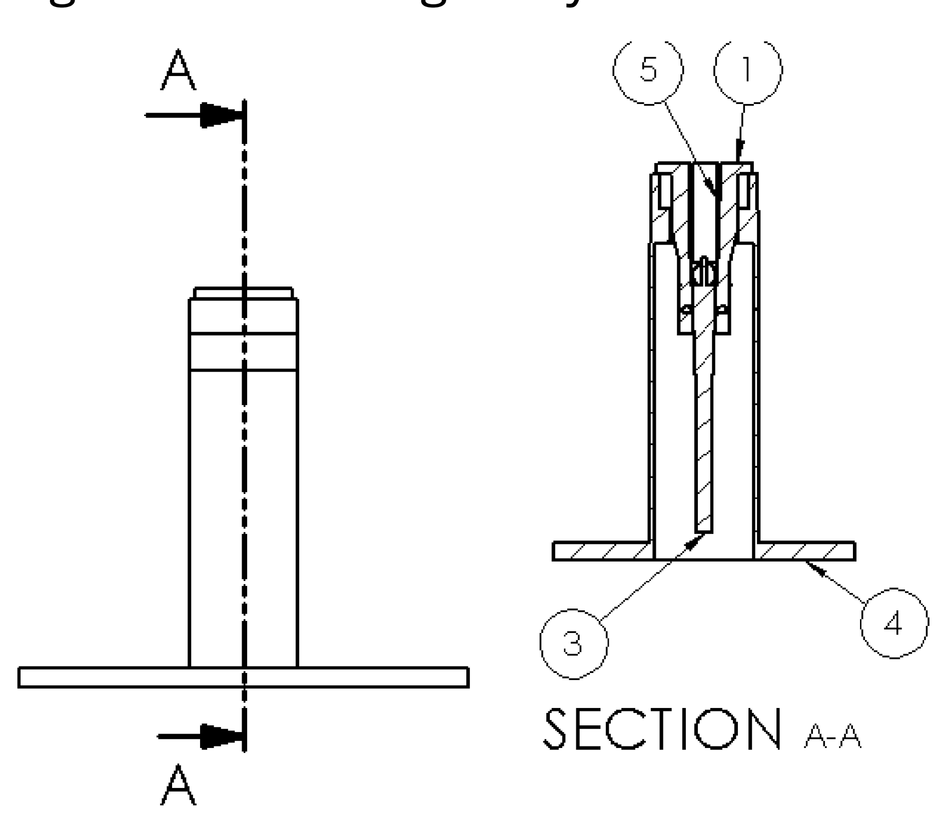
- Growing popularity of liquid handlers and 3D printers in biochemical labs
- Frugal twinning is effective to develop proof of concept self-driving labs



Methodology

- Pick and place tools allow custom tools on OT2
- Electrodes (shown below), cameras, etc.
- These tools expand OT-2's synthesis and characterization capabilities while integrating into the existing ecosystem

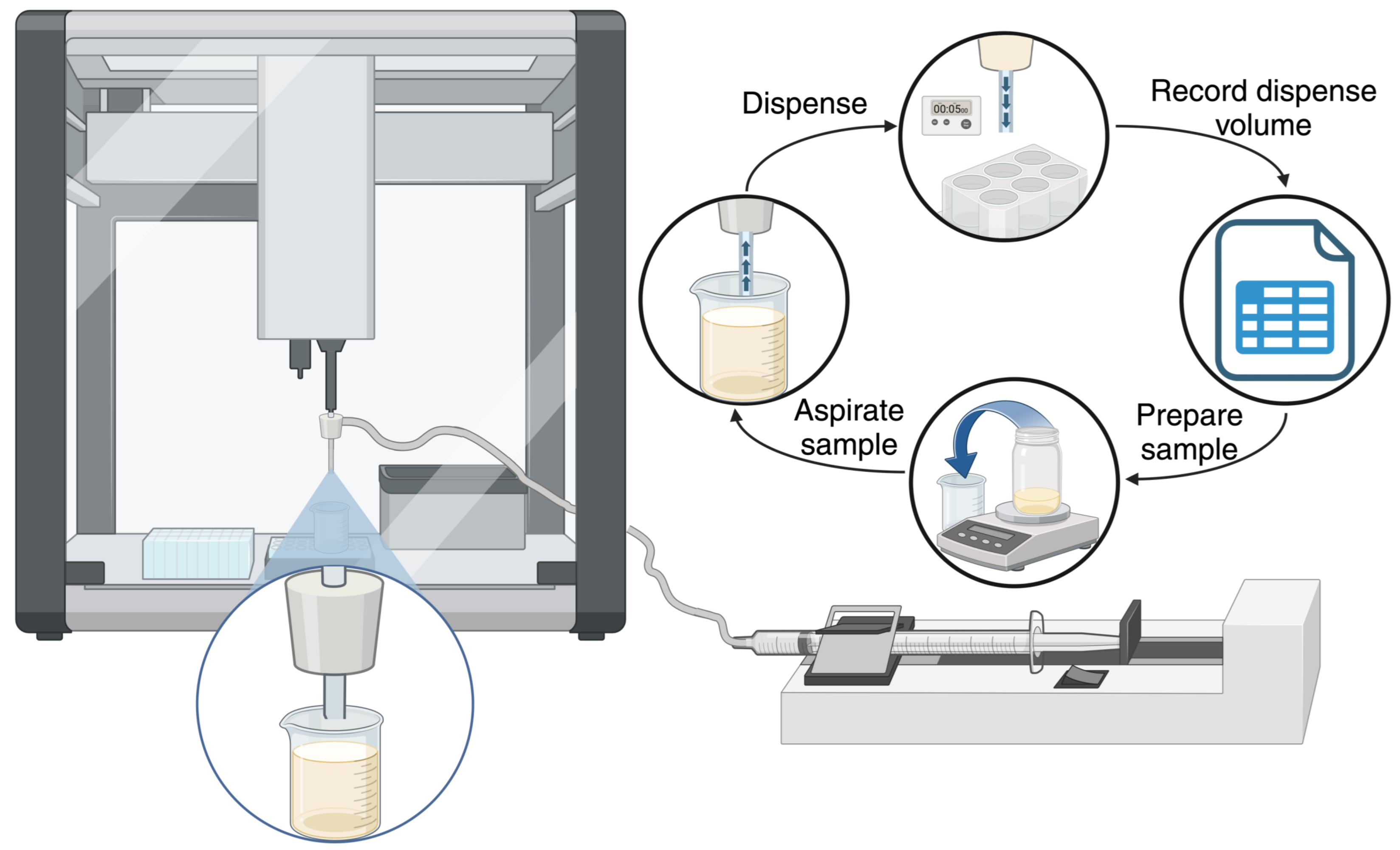




ITEM NO.	PART	QTY.
1	Electrode Holder (Back)	1
2	Electrode Holder (Front)	1
3	Sample Electrode	1
4	Electrode Holder Base	1
5	1000ul Tip	1

- By using an 1000ul pipette tip, the original interface is maintained
  - As a result, the interface can resist up to a 2.4 kg load with default settings

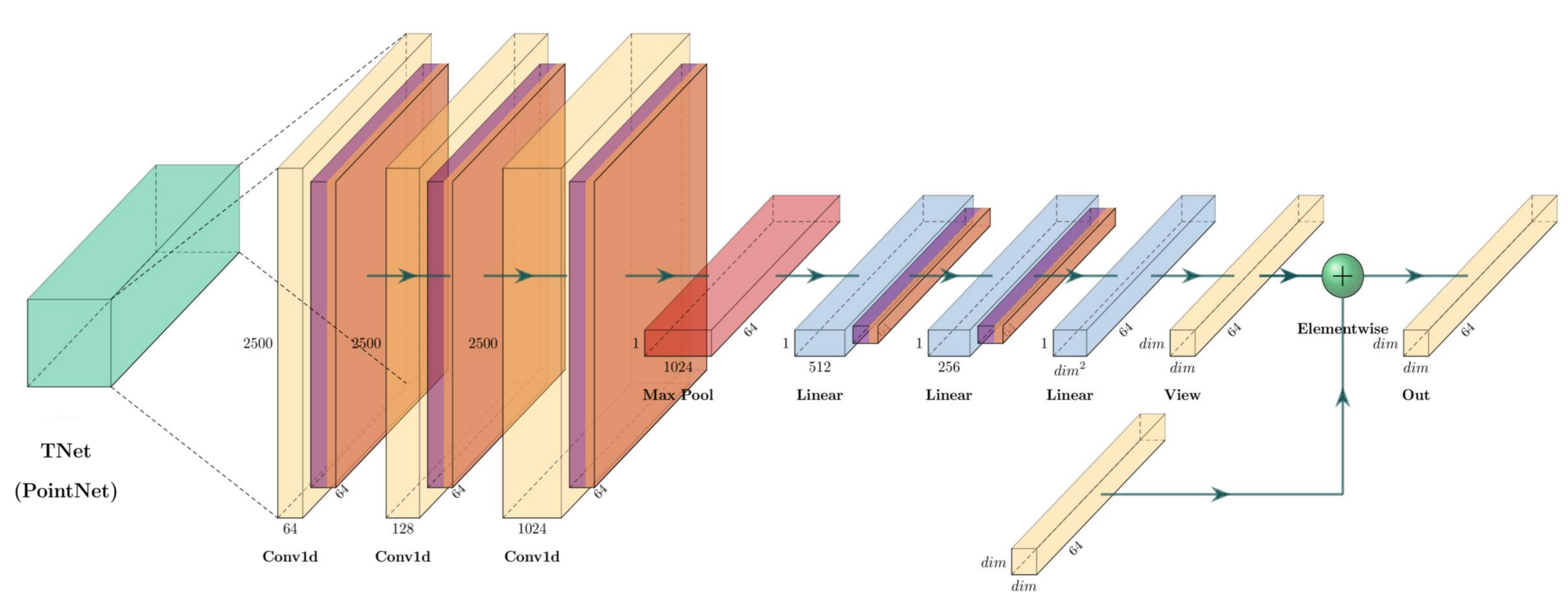
- One application is in automated viscous liquid handling
- We interface a 3D-printed syringe pump [1] with a Raspberry Pico W to control it using the Opentrons API



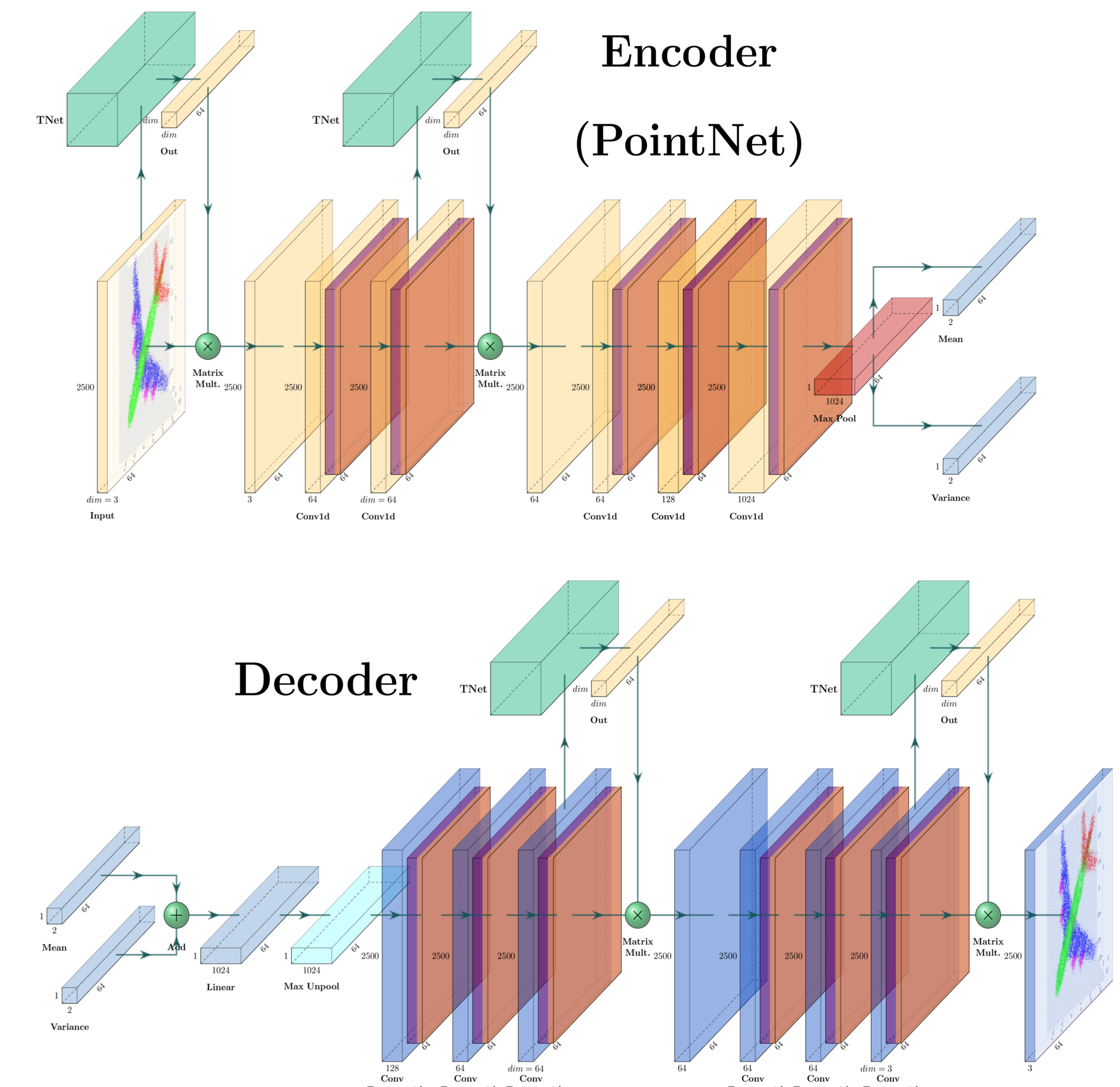
- Applies to handling of topicals, detergent products, and non-Newtonian viscous products
- Can be expanded modularly, where the OT2 connects to different syringe tips

Future Directions

- Design of future tools can be aided by generative ML
- 3D printing collaborative design protocols can be used to automate prototype creation, printing and testing
- PrusaSlicer CLI and OctoPrint automate the printing process



- A convolutional variational auto-encoder (CVAE) was used to train the model on point clouds
- The encoder comes from PointNet architecture [2]
- Using transfer learning, the weights of the model can be updated from real-world tests



Conclusion

Ultimately, these examples illustrate the potential for low-cost lab automation by pushing the capabilities of laboratory equipment beyond their intended scope. We:

- Accelerate low-cost lab automation
- Increase accessibility to self-driving labs
- Illustrate future use of ML in ideating and creating lab tools

References

[1] A. Sina Booeshaghi et al., Principles of open source bioinstrumentation applied to the Poseidon syringe pump system, *Scientific Reports* **9** (12385) 2019.

[2] Charles, R. et al., PointNet: Deep Learning on point sets for 3D classification and segmentation. IEEE Conference on Computer Vision and Pattern Recognition (CVPR). doi.org/10.1109/cvpr.2017.16, 2017

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